Questions to the Science Advisory Panel
From the Washington State Department of Agriculture
Concerning the Introduction of *Anoplohora chinensis* (Forster), citrus longhorned beetle,
Into Tukwila, King County, Washington.

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Science Advisory Panel Member List
David Lance, Ph.D., Entomologist, USDA APHIS Otis Plant Protection Center, Otis ANG Base, MA
Carrol Calkins, Ph.D., Research Leader, USDA Agricultural Research Service, Wapato WA
Bob Haack, Ph.D., Research Entomologist, USDA Forest Service, East Lansing, MI
Kathleen Johnson, Ph.D., Plant Pest and Disease Program Supervisor, Oregon Dept. of Agriculture
Bob Gara, Ph.D., Professor of Forest Entomology, University of Washington

Introductory Statement by the Science Advisory Panel on the Tukwila introduction

This summer, a potentially very serious pest, *Anoplophora chinensis*, also known as the citrus longhorned beetle (CLHB), was accidentally introduced into the environment in Tukwila, Washington. Based on examination of host material (bonsai *Acer*), five beetles are assumed to have escaped from post-entry quarantine (for plant disease) at a nursery. One of the beetles was actually seen flying from the nursery by a WSDA employee. Another three beetles, two males and one female (apparently mated, based on examination of the spermatheca), were recovered before leaving the quarantine area.

The CLHB is considered a major pest of *Citrus*, *Casuarina*, and other trees within its native range in Asia. This insect is closely related to *A. glabripennis*, the Asian longhorned beetle (ALHB), which was recently introduced into the New York City and Chicago areas. In NY and IL, ALHB populations existed for a number of years before being discovered and reported. This gave the population a chance to grow and spread, resulting in very large and expensive eradication efforts. In Tukwila, the actual introduction itself was discovered, providing the opportunity for blocking permanent establishment with a program that is much more limited in geographic area but is very aggressive in terms of tactics and delineation of buffer zones.

The available Asian literature suggests that CLHB is highly polyphagous. Its host range includes trees in many of the genera most commonly attacked by ALHB (for example, *Acer, Populus, Salix*). However, trees in numerous other genera, including *Alnus* and *Quercus*, along with a wide variety of fruit trees, including apples, are also listed. CLHB appears better adapted than ALHB to tropical and subtropical climates, but its range also extends northward well into regions where freezing temperatures are the norm in winter.

Based on the available information, the SAP believes that the introduction into the Tukwila area constitutes a serious threat of becoming a reproducing CLHB population that could spread throughout the Northwest and California, and, eventually, North America. This insect has the potential to become a severe pest of forest ecosystems, urban and suburban shade trees, and/or agriculture in North America. At this point, its potential as a pest certainly should not be considered to be any less than that of ALHB. Sensitive methods for detecting the presence of CLHB are not currently available, and programs will have to rely on visually locating the insect or its damage (which is cryptic initially) to determine presence or absence of the pest. Given all of this, the SAP recommends an active, multifaceted program of survey and control efforts to ensure that the insect does not become permanently established in the Tukwila area. Waiting for definite evidence of a reproducing population before initiating control measures would not be

prudent. In addition, given the "confined" nature of the current population (relative, for example, to ALHB in IL or NY), program managers should consider control tactics, and combinations of tactics, that might be considered unacceptably harsh for use on a broader scale. Those tactics could include, for example, killing larvae by selectively removing known and potential host trees and killing adult beetles by treating remaining (non-host) trees and trees in surrounding buffer areas with foliar insecticide treatments. These actions could be combined with other tactics that are being used in ALHB programs, such as injection of host trees in buffer areas with systemic insecticides.

APHIS-PPQ should take action to eliminate this pest quickly from Washington and block further introductions of CLHB into the United States through the bonsai/penjing and live nursery stock pathways. Given the limited information available on biology and control of CLHB, the USDA (APHIS, ARS, and FS) should also consider developing a supporting research and development program in the country of origin.

Responses of the Science Advisory Panel to questions posed by WSDA:

1. Recognizing that five adults are unaccounted for in Tukwila, should the WSDA assume that the beetles are at-large in the vicinity of the nursery?

Response: Yes.

Discussion: One beetle was actually seen flying from the nursery, and we have to assume that the others did so also. An intensive search of the nursery site with the post entry quarantine materials did not yield any dead CLHB or body parts.

2. Given that a mated female was among the three citrus longhorned beetles (CLHB) found at the nursery in Tukwila and that host material is abundant in the Tukwila area, are five at-large CLHB adults capable of establishing a reproductive population in the Tukwila green belt?

Response: Yes, there is a very high probability that the escaped beetles were potentially capable of establishing a reproducing population.

Discussion: The available evidence suggests that at least one, and probably more than one, mated female left the nursery. There is only a 1 in 32 chance that all five beetles were males, and, because two of the beetles recovered from the site were male and the female that was recovered was mated already as evidenced by sperm in the spermatheca, any females that emigrated from the nursery may also have been mated.

3. Could a Tukwila CLHB population constitute a threat to greater Washington State?

Response: Yes, but not just Washington – the threat would be to the entire Northwest, California, and much of the rest of North America as well.

4. Given that maple trees from Korea were the source of the beetles, can CLHB survive on the locally available host material such as maple, alder, and other hardwoods?

Response: Yes.

Discussion: Specific data on how CLHB will fare on locally available tree species is very limited, but we must take into consideration:

a. CLHB are very polyphagous. That is, the larvae and adults feed on many different tree species. An upcoming review by Steve Lingafelter and Rick Hoebeke lists host plants, based primarily on review of Asian literature, across 26 families of plants. Those species include mostly hardwoods but also a few conifers such *Cryptomeria* and a *Pinus* sp.

b. In Asia, CLHB feed on species that are closely related to trees that are common in the Seattle area, such as numerous species of alder and willow. Hosts also include several species each of maple, oak, and poplar. The insects also attack a large number of tropical, sub-tropical, and temperate fruit trees ranging from guava and loquat to apple. They are considered a major pest of citrus.

c. A closely related insect, the Asian longhorned beetle (ALHB, *Anoplophora glabripennis*), was recently introduced (accidentally) into North America, and was found to prefer a number of North American tree species to species on which it is a serious pest in China. These new North American hosts include 4 genera of trees that the insect has not been reported to attack within its native range.

5. Can CLHB survive the local climate conditions?

Response: Yes.

Discussion: In Asia, the insect's range includes areas with colder winters (Korea) and hotter summers (for example, subtropical areas of China) than it would encounter in the Seattle area.

6. Should the Tukwila situation be considered an introduction of CLHB to Washington State?

Response: Yes.

Discussion: Given the answers to #1 and #2, we have to consider this an introduction and not just a regulatory incident.

7. At what point should a CLHB population be considered an infestation?

Response: When evidence of a reproducing population is found in the field.

Discussion: Although we don't currently have definite proof of an infestation in the Tukwila area, circumstantial evidence (see answers to #1, 2, 4, and 5) suggests a strong likelihood that an infestation is present and will grow if steps are not taken to intervene.

8. At what point should a CLHB population be considered established?

Response: There is a strong likelihood that the population will become permanently established if effective action is not taken soon.

9. Can existing Asian longhorned beetle (ALHB) programs provide a template for a proposed CLHB program in Tukwila even if current ALHB programs are responding to established, expanding populations?

Response: To a limited degree, yes.

Discussion: We can assume that much of the biology of the two insects is similar. However, because the CLHB population has not had a chance to disperse widely nor has produced a generation as yet, the eradication plan should be very aggressive. Options such as prophylactic removal of trees and foliar sprays of insecticides have been ruled out in the ALHB programs because of the area involved but should be considered for use here given the limited size that a current program would have. Also, experience from other eradication efforts indicates that the use of multiple control tactics, against more than one life stage if possible, increases the chances of success. Not being aggressive at this point could result in a very costly and extensive eradication effort later and/or having to live with this very damaging pest.

10. To what extent should the available literature on *Anoplophora glabripennis* in North America be applied to *A. chinensis*?

Response: First, there is very little scientific literature on *A. glabripennis* in North America at this point. We do have information from program experience and unpublished research results that can be brought to bear. Because these two insects appear to occupy a similar niche and are closely related, we can make some inferences from U.S. and Asian literature on ALBH. However, we have to be very sensitive to possible differences between the species that could prove crucial in developing effective eradication and monitoring programs (e.g., lack of oviposition pits observed at least on the bonsai trees, differences in host plant range, etc.).

CLHB is a serious pest of citrus in Japan and China, and it is also studied as a pest of *Casuarina*, alder, and some other species. Because of that, there is probably more Asian literature on CLHB than on its cogener, *A. glabripennis*. This body of literature is already helping to provide a scientific foundation for our efforts and responses to these questions.

11. How far will a typical female CLHB disperse during her adult stage and is it reasonable to assume it to be similar to ALHB?

Response: No firm answer.

Discussion: At this point, we have to assume that the dispersal potential of CLHB is similar to *A. glabripennis*, for lack of a better option. Individual female *A. glabripennis* may move up to a couple of km, though this is probably a fairly rare event.

12. Do female CLHB require a dispersal flight after mating?

Response: Apparently not.

Discussion: The available literature and experience with *A. glabripennis* both suggest that a dispersal flight is not required.

13. What is the likelihood that adult female CLHB were mated prior to dispersing from the nursery?

Response: Very high; see response to question #2.

14. Is *A. chinensis* parthenogenetic?

Response: It's extremely unlikely that this is the case.

15. Will the first visual screen of host trees act as a trap crop for female CLHB dispersing from the Tukwila nursery?

Response: Maybe.

Discussion: This is difficult to predict. If beetles initially orient to and land in plants along that screen, and then find the plants suitable for feeding and oviposition, the answer might well be yes. However, it's possible that beetles may initially fly over or around the first visual screen, or fly to the screen, find the trees there less than fully to their liking, and move on in search of better hosts. Females may also land, oviposit one or more times and then move on to other trees. Because females are likely to move among trees during the course of their oviposition period, we cannot assume that all or even most oviposition (assuming it occurs at all) will take place within the first visual screen.

16. Will CLHB recycle in an individual host tree over several generations?

Response: Most likely.

Discussion: This happens with ALHB and some of the indications in the literature are that it will happen with CLHB too. Based on the limited information available, we have to presume that most females will begin laying eggs in or near the host they emerged from, but will also move between hosts during their lifetime. Disturbances (e.g., by potential predators) and local shortages of resources (e.g., mates, food, or oviposition substrates) will tend to increase the distances that females move.

17. Will CLHB use the entire structure of a host tree or will CLHB be limited to the trunk and roots?

Response: We have to assume that immature stages of CLHB can potentially be found anywhere within the entire trunk, above-ground (at least) portions of roots, and larger branches of a tree.

Discussion: We are working with our collaborators in China and Japan to get more specific information on this. From what we have seen in the literature and heard from collaborators, CLHB may tend to attack generally lower on trees than do *A. glabripennis*, but point of attack seems to be variable. For example, reports in the citrus literature indicate that CLHB typically oviposit within a few feet of the ground. In contrast, a contact in Japan said that, at least on *Melia*, CLHB will attack "the upper parts of the trunk". An APHIS-PPQ-affiliated scientist (Baode Wang) recently (10/2001) visited sites in southern China where CLHB is prevalent. He reported that, on small *Casuarina* (<30 cm diameter; they were harvested at about this size), beetles oviposited very near the ground, but on neem trees in the same area, most activity was high in the canopy. Height of the attack point probably is a function of several variables, including tree size and species, bark thickness, and distance to feeding sites (twigs, leaves, etc.). Understanding where these beetles oviposit is very important to an eradication effort, in terms of both designing survey protocols and determining the possible utility of trunk sprays as a control measure. Many trees in the Tukwila area are large with high canopies and relatively thick bark near their bases, so surveys should, initially at least, include the upper as well as lower portions of the trees. Further literature searches and discussions with contacts in Asia should produce a better answer to this critical question.

18. Will CLHB kill host trees?

Response: Yes, in all likelihood.

19. Is CLHB a primary tree pest or secondary tree pest?

Response: Primary

20. If CLHB becomes established, will host trees be functionally removed from the forest ecosystem over extended areas?

Response: Quite possibly or even probably. Certainly, it is not safe to assume that this won't occur.

Discussion: Given the pest status of the insect in its native range, its broad host range, and our experience with *A. glabripennis* in North America, we have to believe that the insect has the potential to do this (see answers to questions #4 and #18). The purpose of eradication is to *not* let the pest become established and (among other things) functionally remove various taxa from the forest ecosystem.

21. If CLHB host tree genera are functionally removed from the forest ecosystem, what effect will that have on the regional ecosystem?

Response: Forest ecosystems are complex, making it very difficult to predict consequences of selectively removing species or genera. Removal of common species of dominant or co-dominant trees could obviously affect levels and balance of food and shelter available for wildlife, understory composition, and, directly or indirectly, most other characteristics of the ecosystem. Because a number of the beetle's potential hosts are common in riparian areas, even salmon could potentially be affected.

22. How effective would tree removal be at eradicating CLHB?

Response: Tree removal (and chipping or chipping and burning) is currently the only 100% effective method that we have for killing immature *Anoplophora* in host trees. Thus, it would be very effective if *all* infested trees were removed.

Discussion: Given the inefficiency of available survey technology in finding *Anoplophora*, we *do not* recommend (initially) removing only trees that are found to be infested, or at least not relying on this tactic to eradicate the population. Survey and removal only of trees known to be infested is being practiced in the NY and IL programs to eradicate ALHB. In many cases, individual trees or groups of trees that were initially left standing have subsequently been cut down after follow-up surveys demonstrated that they were infested all along (but signs of infestation had not been seen the first or even the second time through). ALHB program managers are now augmenting tree removal by prophylactically treating all host trees across large areas with systemic insecticides.

23. If a tree is removed, can larvae survive in the remaining stumps?

Response: Yes, if they are there.

24. Is there an alternative method to tree removal that provides complete destruction of CLHB larvae in a host tree?

Response: Not at present.

25. How effective are systemic pesticide injectors at eradicating CLHB?

Response: With *A. glabripennis*, systemic insecticides are considered a supplementary control tactic that lower beetle populations in the infested area and help prevent uninfested trees from becoming infested. We have to assume that they would have, if anything, a similar role in CLHB eradication. They should by no means be considered as a stand-alone or even primary eradication tactic, but they are considered a valuable tool in multi-faceted program.

Discussion: To date, most tests of systemic insecticides have concentrated on the use of Imidicloprid, which is relatively non-toxic to mammals and is already registered for use against tree-boring insects. Alternative insecticides (e.g., Bidrin) could potentially prove more effective but have not been evaluated for use in *Anoplophora* programs due to environmental and/or health concerns related to their use.

In China, trees treated with Imidicloprid, either through trunk injection (e.g., with the Mauget system) or soil injection, have been dissected and examined for effects on larvae and adult emergence. Mortality of immature ALHB attributable to treatment has generally been fairly low (<50%). However, counts of adult beetles beneath treated trees and effects of treatment on beetles caged on trees suggest that the systemic insecticides are relatively much more effective on adult beetles than on the immatures. This news has to be tempered, though, with data indicating that concentrations of Imidicloprid attained in the

twigs (what the adults feed on) of Chinese poplar trees seem to be generally higher than those we've observed in the larger maples and elms that are being treated here in the U.S. (also see response #26).

26. What diameter trees should be considered for systemic pesticide injections?

Response: If Maugets or similar trunk injection systems are used, trees below 2 inches in diameter generally are not treated. With soil injection, any tree may be treated

Discussion: There is no upper limit on size for treatment. However, label rates for systemic insecticide injection are typically based on linear measurements (for example, diameter at breast height, or dbh) whereas tissues that the insecticides must permeate will increase area-wise and/or volumetrically with increases in dbh. Because of this, concentrations of systemic insecticides in trees would theoretically be expected to be lower in larger trees than in smaller ones, and the available experimental data seem to support this.

27. How effective are broadcast pesticide sprays at eradicating CLHB?

Response: ALHB beetles were killed readily by most contact and stomach-poison insecticides that have been tested against them (these include, among others, Sevin, Permethrin, Chlorpyrifos, Lindane, and Acephate), and trunk sprays are routinely used for CLHB management in citrus. However, most of these insecticides have fairly short residual lives and thus would require multiple sprays during the period of adult activity if programs were relying on adult control for eradication. The rain typical of the Seattle area would likely increase the required frequency of sprays. If insecticides that act primarily as stomach poisons are used, coverage of appropriate substrates (specifically, bark of twigs) could also become a logistical issue. Still, broadcast pesticide sprays could be very beneficial in augmenting other control tactics and helping to achieve a desired level of overall control, leading to eradication. Method of application may also be a problem. Aerial applications are publicly and politically unpopular and, in this case, might not be able to deliver the necessary coverage of appropriate surfaces (twigs, limbs, trunks). Hydraulic sprayers and mist blowers should be considered as alternatives.

In Japan, an entomopathic fungus is registered for control of CLHB in citrus. Tests by U.S. scientists indicate that, with *A. glabripennis*, this fungus produces moderate levels of mortality (well less than those produced by chemical insecticides) when used under controlled (i.e., relatively ideal) conditions, so it's very doubtful that this fungus could provide more than a very modest boost as a component of an eradication effort.

28. How effective are pesticide trunk applications at eradicating CLHB?

Response: It is difficult for us to predict at this point.

Discussion: This tactic appears to be used routinely for management of CLHB in citrus. Effectiveness in this case would depend in large part on where the insects lay their eggs (see response to question #17).

29. Can CLHB be eradicated or controlled with conventional pesticide applications?

Response: It is doubtful that the use of conventionally applied pesticides *alone* would result in successfully eradicating a CLHB infestation, especially given the limitations mentioned above (#27). However, use of pesticides should be considered as an important and integral component of a CLB eradication effort.

30. Will surveying host trees in the area of an introduction provide useful information to an initial CLHB eradication program?

Response: Yes

Discussion: One of the most critical portions of eradication programs is knowing where and how many pests are present. Given the way this situation started, we have some idea of this already and, in that aspect, are ahead of where a lot of other eradication efforts start. However, being able to locate infested trees efficiently will become critical to the eradication effort

One problem at this point is deciding just what to look for during surveys. Oviposition slits are apparently very difficult to detect, especially on thinner-barked trees. However, at least one published report indicates that frass is ejected from these sites, which would give surveyors something "findable" to look for. Sap staining may also be present on some infested trees. WSDA scientists have suggested looking for signs of adult feeding (twigs stripped of bark) in the canopy; this is a possibility, but the SAP members generally felt that finding such damage could prove very difficult.

31. Should a winter 2002 survey be conducted even though any adult emergence associated with the summer 2001 introduction will not have yet occurred?

Response: Yes.

Discussion: Any information on where the insects are or how readily we can find them will be very useful to the project. Finding any larvae that are feeding out there, for example, would provide information on host acceptance, indicate areas where eradication efforts should be concentrated, and help boost public and political acceptance of eradication efforts.

A second issue: the occurrence of emergence of CLHB at two separate sites in the Seattle/Tacoma area this year begs the question of whether this pathway may have been bringing CLHB into the area for some time. Surveyors should also be looking for exit holes that may indicate the presence of older infestations.

32. What would negative results from the first survey (winter 2002) mean for an eradication program?

Response: It would mean that any potential benefits of finding infested material during the survey would be lost, and nothing more. Most importantly, due to difficulties inherent in finding CLHB damage (especially when small numbers of insects are present), negative results cannot be construed to mean that the insect is not present in the area or that programmatic responses to a potential infestation can be reduced safely.

33. Should a second survey be planned for the following winter (2003) even if the 2002 survey produces negative results?

Response: Most definitely (see #34).

34. Given the experience with ALHB, should the CLHB survey last a minimum of 5 years?

Response: Yes.

Discussion: Given the inefficiency of visual surveys and the probabilistic nature of insect detection efforts, survey should be continued for a minimum of five generations (years) in order to be reasonably certain that the insects are not reproducing in the area.

35. Does host tree material such as pruned branches, firewood and nursery stock present a pathway for the spread of CLHB?

Response: Absolutely, if our experience with *A. glabripennis* is an indication.

Discussion: The infestations of *A. glabripennis* in Amityville, NY and near O'Hare airport were known to have been started by landscaping professionals who held wood from tree-trimming operations within infested areas (Brooklyn and Ravenswood, respectively) at those sites. There is circumstantial evidence that other satellite infestations in NY were started in a similar manner. In addition, the Ravenswood infestation was initially discovered through the presence of beetles in the capped bed of a pickup that had been used to carry wood from the infested area. Stopping movement of wood out of an *Anoplophora* infestation is key to stopping satellite infestations that greatly accelerate the spread of the insect.

36. Can bonsai material that has been inspected for damage and then kept indoors during the oviposition season be sold without the threat of spreading CLHB?

Response: The SAP recommends that the bonsai and penjing materials be held for *two* oviposition seasons before being released.

Discussion: Under some conditions/areas, *Anoplophora* beetles are known to require two years to complete a generation. Populations from the northern portions of the species' range (Korea, for example, in the case of *chinensis*) may tend to exhibit this trait to a greater degree than those from more southern areas. Given the relative cost of holding trees for an extra year versus an eradication program (or, worse, establishment of CLHB in North America), we suggest erring on the side of caution here.

37. Can nursery stock, such as young maple trees, be adequately examined though visual or acoustic methods to certify it as non-infested in order to safely allow it to leave a quarantine area?

Response: At this point, no.

Discussion: The oviposition marks can be quite cryptic, especially on small, thin-barked trees. For example, WSDA workers were unable to positively identify oviposition sites even on bonsai trees that they knew were infested. As a result, finding evidence of CLHB infestation during routine inspections is by no means guaranteed. Acoustic methods are still under development.

38. Can nursery stock, such as young maple trees, be adequately treated with insecticides to certify it as non-infested in order to safely allow it to leave a quarantine area?

Response: At this point, no.

Discussion: APHIS scientists are currently looking at the use of systemic insecticides against *Anoplophora* beetles in potted trees. Results of those studies *may* provide an adequate treatment at some point in the future, although, given results obtained thus far with in-ground trees, prospects for an "approvable" treatment are not good. As an alternative, fumigation is routinely used to kill external pests on dormant stock, along with internal pest insects on specific fruit, solid wood packing materials, and some other commodities. Unfortunately, quarantine treatment specialists in APHIS have indicated that fumigation schedules capable of killing internal pests within bonsai, penjing, or nursery stock would also result in the death of those trees.